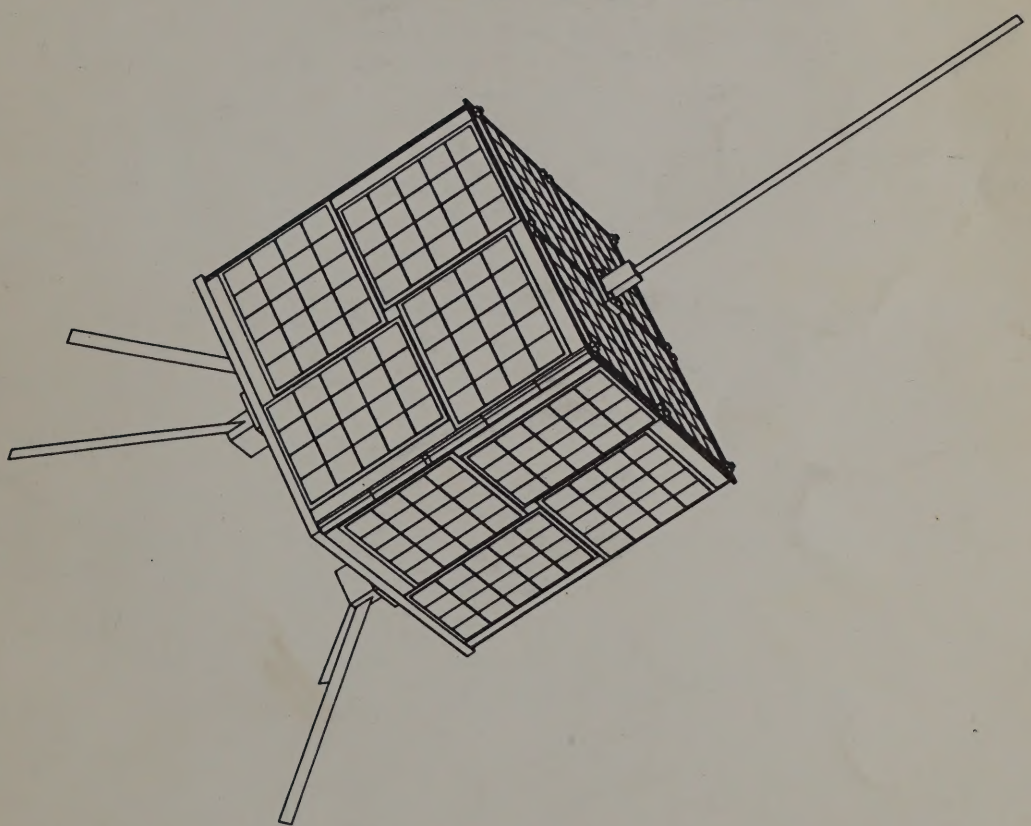
THE PACSAT BEGINNER'S GUIDE



AMSAT'S complete step-by-step instruction guide to operating through the PACSATS. All necessary software is included.

FOREWORD

This is the first published draft of this Guide. AMSAT has a lot more material planned for inclusion into this Guide before it is printed in final form in about three months. Among the things planned for inclusion are more figures, tables and other information on the pacsat program that will make your efforts in this area more enjoyable and fulfilling. There is however ample information in this edition to get you up and started using the pacsats. We have also included our first ever "Elmers" listing of amateurs who are now on the pacsats and stand ready to help you with any hard spots that this Guide doesn't adequately cover. If you will use the registration form included in this beginners package and send it along with $5.00 to AMSAT headquarters we will see that one of the final copies of this Guide is promptly mailed to you.

I only edited this document; many from AMSAT had significant input, most notably Dusty Warner KF4AU, Courtany Duncan N5BF, Harold Price NK6K, and Bruce Rahn WB9ANQ. A special thanks goes to John Kuklinski, N4PLY who was my "Elmer". When you have finished reading it and hopefully putting it to use please take the time to share your comments with me so I may make this a much better tool in the next edition. As you will find out much of the important information in this document is on the diskette that accompanies it. The text will tell you what to do with that diskette and when. Please wait until that time.

If the pacsat programs that are on the diskette have been significantly revised by the time that the final of this Guide is issued you will receive a new diskette also.

Thanks,

Mike Crisler, N4IFD
Dayton, Ohio
April 1991

JUST WHAT IS AMSAT?

AMSAT is a word you are going to hear a lot when you are involved with amateur satellites. AMSAT is an acronym for the Amateur Radio Satellite Corporation. AMSAT is a non-profit, tax-exempt 501(c)(3), scientific corporation founded in the greater Washington, D.C. area in early 1969. We now have approximately 6500 members and are dedicated to keeping Amateur radio in space!

As you can imagine, building and placing an amateur satellite into orbit is a very expensive proposition, even though a lot of contributions and "low cost rides" are available. AMSAT is the voluntary body that provides this most important and many other supporting functions to the Amateur Satellite Community. The key is that AMSAT is totally voluntary. They don't have a large paid staff. Mostly it is just people like me, and like I hope you will be someday, who volunteer their time and money to support the amateur satellite program. Why all this effort and what does all this gain for us? We gain new and valuable frequency space, totally unaffected by the vagaries of sunspots and the ionosphere, to make those QSOs and file transfers that we find so enjoyable.

Included with this Guide (in the Compendium) is a membership application for AMSAT. Joining this organization will do several things that will help you with your endeavors in the amateur satellite program. First , through its **JOURNAL** AMSAT will bring the latest in operating hints and technical articles right to your shack. As you continue to read this Guide we will frequently refer to articles previously published in this excellent publication. It will be a real help in all of your satellite endeavors. Second, the **JOURNAL** will bring you articles from the designers and builders of these satellite that will help you understand the how and why of their operation. It will also bring you orbital elements and schedules-but by the time you get that first issue you will probably be downloading those off of one of the pacsats!

Probably the most important reason to belong to AMSAT is that about half of the money you send AMSAT is earmarked for new satellite construction. As you begin to use and enjoy the birds that are now up and operating think seriously about becoming a supporter so that hams in the future as well as you and I can continue to enjoy the rare privilege of actually sending a signal into space and getting an answer back!

PACSAT BEGINNER'S GUIDE

Introduction

AMSAT has long had a dream of providing a store and forward satellite for use by the amateur community. In fact this concept was first introduced in the May 1984 issue of "BYTE" magazine. On 22 January 1990 that dream became a reality as six new OSCARs (Orbiting Satellites Carrying Amateur Radio) were placed into orbit by the Ariane V-35 launch vehicle that was launched from Kourou, French Guiana in South America. These "birds" are now for the most part operational and waiting for you to upload a message to another ham anywhere in the world. By the nature of their polar orbits, these satellites will pass over every spot on earth at least four times a day!

My first experience with these powerful mailboxes in the sky came one evening as I was reading the directory of the files that were available on one of the pacsats-AO-16. To my overwhelming surprise, there was a file addressed to me, N4IFD! I downloaded that file and read it when the pass was over. It was a message from a ham in Italy that had received a QSL card from me for an OSCAR-13 QSO and just wanted to say thanks. I quickly composed an answer to my new friend and uploaded it on the next pass. I have since had many messages from "the Continent", in fact from several continents. This Beginner's Guide will lead you step by step through doing just what I've described. It will also introduce you to the many other things the pacsats can do.

JUST WHAT IS A "PACSAT"?

In the opening paragraphs several terms have been used that may not be familiar to you yet. They will be before you are done with this booklet! This Guide will attempt to define and describe each such special term when it is first used. A pacsat is a satellite capable of performing something akin to normal packet radio functions, much as a digipeater or packet bulletin board service (PBBS). The real advantage is that now this digipeater/PBBS is in space and moves continuously so its antenna pattern or footprint covers all the surface area of the earth several times daily. The altitude of a pacsat (like the height of a digipeater's antenna) is over five hundred miles so it can allow me from my Miami, Fl. QTH to digi directly with a ham in California or Canada! Since a pacsat moves so fast this type of QSO can a best last several minutes and with the way most of us type not much information is likely to be exchanged.

What a pacsat does best is take a file or message I have composed or am forwarding from a land based link and then

NOTES:
* AO-21 AND FO-20 have a voice transponder as well as the digital channel. The use of these satellites is described in articles published in the **JOURNAL** and is beyond the scope of this Guide.

UO-14 is like the other pacsats except that it uplinks/downlinks at 9600 baud. Such a rapid rate of transmission requires some internal mods to your rigs. An appendix to this Guide that will be in the final publication will discuss these modifications for all popular rigs and the operation of this satellite. Though not all that difficult, this is not a satellite for the first time user.

UO-15, which was launched with the other five microsats has malfunctioned in space and is no longer operational.

Two of the microsats launched in January 1990, DO-17 or DOVE and WO-18 or WEBERSAT, are downlink only satellites and will be covered in a separate appendix which will also be in the final version of this Guide. DOVE is also discussed in the Compendium that you received with this Guide

This Guide will concentrate primarily on the use of PACSAT and LUSAT. This Guide will not attempt to cover all possible ways to connect to these pacsats but will cover the main ones in a step by step fashion.

WHAT'S ALL THIS STUFF ABOUT LINKS AND MODES?

Connection to a pacsat or any satellite, requires two things: an uplink and a downlink.

Uplink is the term used to indicate the transmission of data (or voice) up to the satellite. This activity is very similar to "uploading" a file to a PBBS/BBS.

Downlink is the term used to refer to the satellite transmission of data down to the ground station (you). This is also similar to a "download" from a BBS. There is one BIG difference that you must take into account as you set up a station for pacsat operation. Pacsats do this up and down linking at the same time. This is called full duplex.

Full duplex in RF terms; it's much like a telephone conversation as you can talk and hear at the same time. It is very important that as you purchase and set up your station that you keep this in mind so that any possible "crosstalk" or receiver desense caused by our transmitter in our received or downlink signal can be minimized. In packet terms you will have "FULLDUP" set to on.

To allow the satellite to work full duplex two separate bands

are used for the uplink and downlink. If you have ever seen the duplexers used on 2 meters and 440 Mhz you know how big they are. You may have even had the opportunity (?) to carry one of these up to an elevated repeater site and know first hand how heavy they are. To make a long story short they are too big and heavy to launch into space. Remember, the "microsats" are only nine inch cubes-no room there for a duplexer. Consequently satellites transmit on one band and receive on a completely different one in full duplex fashion. There is a "hidden" benefit to this type of operation-we eliminate a lot of the "doubling" that is all to common on "simplex" repeaters.

Mode J consist of an uplink on 145 Mhz with a corresponding downlink on 437 Mhz. These frequencies are located in the Satellite Subbands of the 2 meter and 70 centimeters Amateur bands. The combination of these bands is referred to as a "mode". When used on the pacsats this mode is sometimes referred to as Mode JD, with the D indicating digital.(FO-20 and OSCAR-13 have voice (or analog) Mode J transponders aboard them that allow voice QSOs.) When you are selecting the rigs/antennas for your station this is worth remembering as for a few more dollars you may also be able to operate on these transponders. Check the "Frequency Guide" in the Compendium for more details on other modes in the satellite service. As you read the sections concerning the equipment and antennas needed, it will be advantageous for you to review this material and procure the gear that will support operation of the largest number of modes for the depth of your pocketbook.

Another excellent source of ideas and practices that should be followed in setting up a satellite station is AMSAT's "Beginner's Guide to OSCAR-13". I would strongly recommend that as you consider the gear you will be purchasing, look into the possibility of getting gear that will ultimately allow you to work all of the amateur satellites.

WHAT WOULD A SIMPLE PACSAT STATION CONSIST OF?

Generally when most radio amateurs think of satellite stations they envision having to mortgage their home and begin eyeing the kids' college tuition fund. It is not that way. In fact, one of the design goals of the Microsat program was to simplify some of the station requirements. In the following sections I will begin to discuss the basics of transmitting to and receiving from the pacsats with an emphasis on economy and simplicity. This Guide will not cover every possible combination of equipment. Instead I am going to make some personal recommendations of several ways to successfully download and then upload your first file to a pacsat.

In a file called ELMERS.TXT on the diskette that you received with this Guide you will find what may be the most useful part of this Guide-"The Pacsat Elmers List" This is a list of amateurs who

are up and running on the pacsats AND are willing to answer your specific questions about the gear and techniques it takes to be successful. The list contains a description of their stations so that you can find an Elmer with gear like you have or intend to acquire and ask those questions that are not covered in this Guide. Please respect their request as far a the time you call these unselfish amateurs.

THE SIMPLE PACSAT STATION

This is a quick description of a simple station; it contains all the basic parts necessary for successful operation. You can make many variations on the component parts without effecting the ability of the station to communicate.

The station consist of: a two meter FM transmitter with a small amplifier capable of about 50 watts; a sensitive receiver capable of SSB on 437 Mhz, a simple dual band vertical antenna (or two independent vertical antennas) such as the J-pole described in the attached **"Getting Started on Amateur Radio Satellites"** Compendium, and a mast mounted preamplifier for 437 Mhz capable of at least 10 dB of gain with a small noise figure. The stuff you don't have, chances are you can build relatively inexpensively. All of this should be connected with Belden 9913 coax or its equivalent to minimize losses.

From the data processing end you will need a MS DOS compatible PC with a modest amount of memory, a TNC that can be used with an external modem, and the external PSK modem (this one specialized piece will be described in detail later). The software you need is on the disk included with this Guide.

The following sections will discuss each of these pieces of gear in detail. Again if your questions are not answered here then refer to the Elmers List.

THE RECEIVER

First let's look at the receiving requirements. The pacsats covered by this Guide (as well as several other amateur satellites) have their output in the 70 centimeter band between 435 and 438 MHz (UO-14, AO-16, WO-18, LO-19 not to mention FO-20, AO-21 and AO-13 mode J/L - see the **"AMATEUR SATELLITE FREQUENCY GUIDE"** in the attached Compendium). Why this higher band and not 2 Meters? Well in many parts of the world 2 meters is very crowded with high power repeaters, packet BBS etc. That makes it somewhat difficult to hear a relatively low powered satellite 500 miles km out in space. On the other hand the 437 megahertz band is very quite even in heavily populated areas.

For receiving sideband from the AO-16 and LO-19 your gear must operate within the 437 mhz portion of the band. Any of the commercially available "all-mode" rigs for 70 centimeters will do nicely. If you have one of these you are in excellent shape for the downlink portion of your pacsat station.

There are also many of these all mode rigs on the used market. Pay particular attention to 435-438 receiving range when shopping for some of the older 70 centimeter rigs. For example, the old KLM ECHO-70 will only cover the bottom portion of 435 MHz. Although there are not a lot of second hand all mode rigs around on 70 cm, a careful review of some of the specialized "ham trader sheets" will turn up several. Review the Elmers List for some ideas on these receivers.

You can expect to pay $1,000 plus for a new all mode base rig. All the major manufacturers provide an excellent selection of such rigs but they are not cheap. Granted, all you need is the receiver, but a receiver such as the ICOM R-7000 is in the same general price range. The following sections will discuss the much less expensive converter route that will utilize your HF rig for receiving the downlink.

One final note, in selection of a receiver, pay particular attention to whether the tuning can be accomplished externally, i.e. by using up/down buttons on the microphone or possibly on the later rigs by a din connector/direct RS-232 input into the back panel of the rig. The available PSK units that will be used for your data acquisition has the ability to tune your 70 centimeter rig and lock on to the satellite's downlink signal and automatically adjust for the Doppler shift throughout the entire pass. They do this by applying voltage pulses to the frequency control input on the up/down pin of your mike connector. This is a very important option to look for and becomes essential if you ever intend to try unattended operation.

CONVERTERS

If you can't afford to purchase transmitter/receiver stand-alone units for 2 meter and 70 centimeters, you might consider building or buying converters for these bands. It's an excellent way to get your feet wet at a relatively low cost. As you can see in the Elmers List there are people using this method quite successfully!

A receive converter simply converts the 70 centimeter signal from the satellite to a 10 meter signal that can be handled by your HF rig. For example, if you were looking for AO-16 which downlinks on 437.025 you might typically tune your 10 mtr rig to 29.025. You don't need a complete transverter which would both transmit and receive on that frequency - just the receiver part. Units are available from places such as Advanced Receiver Research, RadioKit

and Hamtronics. Just be sure that you specify to them that you want a receive converter with coverage from 435 to 437.2 so the manufacturer can install the right crystal for the local oscillator in the converter. Another good place to look for equipment sources is the **SATELLITE EXPERIMENTER'S HANDBOOK.**

Caution, make sure you have some positive way of disconnecting the receive converter when using the transmit side of your 10 mtr rig or you will fry your converter (personal observation of smoke here). Either obtain a switch with good isolation or disconnect the coax when you're done. It only took me one nanosecond or so of RF through the converter I had found at a swap meet to "convert" it to junk! BE CAREFUL!

You might also find a transverter (a transverter both receives and transmits) such as a Microwave Modules unit or an SSB Electronics unit for sale second hand. You may have to change the local oscillator frequency to get it up to 437 MHz since such units typically operate at a frequency of 432 MHz. But it's normally just a change of crystal. Keep in mind the frequency you are working with when shopping the hamfests. It's 437 MHz, not 435 or 432. Generally 70 centimeter converters or transverter units will give you 2 MHz of tuneable range in the 70 centimeter band.

If you find a one of these look on the unit to find the conversion or ask the owner what it tunes. Lets say you find one but it tunes 432-434 MHz converting to 28 to 30 MHz. You should be able to change the conversion by changing the local oscillator frequency crystal. Open up the unit and find the crystal. When you have found it look for a number imprinted on it. This number is more than likely the fundamental frequency (not the local oscillator frequency). For example, say it reads 101.000 stamped on the top. If it was designed for 432- 434 MHz / 28-30 MHz operation you're working with a 4X (times four) multiplier chain using 101 MHz as a fundamental.

A simple calculation gives us::

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70 cm tune    = 432
10 mtr IF     =  28  (subtract)
L.O.          = 404 MHz  crystal ( 101 x 4 = 404)

Since you want to retune for 437 MHz
70 cm tune     =437
10 mtr IF      =  28
NEW L.O.       = 409 MHz
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Since you have a times 4 multiplier divide 409 by 4 = 102.25 MHz for the new fundamental frequency. Now all you have to do is obtain a new crystal cut for 102.25 MHz. In the back of most of the ham radio magazines you find several companies that will cut a single crystal for 15-25 dollars. I have been using Jan Crystal

in Florida for several years and they will cut such a crystal for $15. When you complete the installation of the new crystal you may have to retune the tank circuit a bit to get it to start reliably. If you see a trimmer cap or coil near the crystal it is more than likely in the tank circuit. If it won't oscillate try carefully tweaking the trimmers and it will probably start oscillating. If you have a frequency counter put it on the circuit and adjust the components for the right frequency. Then you can peak all the multiplier stages for maximum output using an on the air signal (3rd harmonic of your 2 mtr rig works in a pinch..... 145.666 x 3 = 437 MHz.)

I would also refer you to Ed Krome's (KA9LNV) excellent article entitled "Design of an Easy to Build, Versatile, Homegrown Satellite Ground Station" that covers construction of two converters in detail. This article is available from AMSAT Headquarters.

THE TRANSMITTER

You are probably wondering if you can use your 2 meter FM rig on the uplink? Yes, in most instances you can. Depending on your antenna system modest power levels of 25-50 watts should link you into the bird. If this doesn't work you might try boosting your power with a small amplifier or improving the gain of your antenna system. Remember as always in Amateur radio-USE THE MINIMUM POWER NECESSARY TO MAINTAIN COMMUNICATIONS.

As you select a rig for the uplink you should keep a couple of other things in mind. First, establish whether or not the rig can be set up easily for packet. Some newer units have a separate connector on the back just for data communications, if so, great. You will be imputing an audio stream of data from your TNC into the rig much as the mike inputs your voice. If the rig you intend to use does not have this feature all you have to do is identify which pins on the mike jack are for the audio in and push-to-talk line. You will have to obtain a spare mic connector and cable it to the TNC output. The only disadvantage to this is if you also use your 2 meter rig for voice you will be continually swapping plugs. (If you have a Double throw Double pole switch around you can hard wire up a little toggle control to change back and forth without undoing everything.)

DOPPLER SHIFT-AND HOW IT AFFECTS US

You have probably stood by a railroad track and heard the pitch of the train whistle change as the train approaches and then passes. That change in pitch was very real to our ears even though the frequency of sound coming out of the whistle remained constant. We heard a change in pitch because the source of the sound was moving rapidly toward or away from us. We received and heard a

slightly higher frequency (or pitch) as the train came toward us and a slightly lower frequency as the train moved away from us.

The pacsats move a whole lot quicker than a locomotive, even much faster than a speeding bullet. Hence, we encounter an RF frequency shift, called the doppler shift, as the satellite moves away or toward the receiving station in its orbit. It is this doppler shift that causes the need to make corrections to the frequency of the ground station receiver during a pacsat pass. In pacsat operation the doppler shift on the downlink is accommodated by continuously tuning the downlink. The PSK-1 modem's output to the up/down mic buttons does this arduous task for us-hence the reason to pick a receiver with this remote tuning capability.

Corrections would also be necessary to the signal received at the satellite-which could only be made at the transmitter-since it is not possible for each station to remotely tune the VFO of the satellite. Fortunately the brilliance of the designers of the pacsats have taken advantage of some basic RF engineering to all but alleviate any concerns for doppler tuning of that uplink signal.

This is where the deviation of your rig comes into play. FM is by its very nature a wide band mode; the satellites receiver is an FM receiver for that very reason. By adjusting the deviation of the ground station's transmitted signal to between 2.5 and 3.5 Khz (verses the 5 or 6 found on most FM rigs) the "wide bandedness" of the satellite's receiver can adequately receive our now relatively "narrow banded" uplink throughout the whole pass without the need for us to adjust it! Getting this set right on your transmitter is very important. You could have everything else right with your station and this seeming small thing would keep you from uplinking. Either find a friend with the appropriate equipment to help you set the deviation on your rig or consider having a ham radio repair shop to do it for you. Find one of the Elmers with a rig like yours and ask for his advice on this very important subject.

If all else fails ask a friend to listen to your transmitted signal on a 2 meter HT while you turn down the mic gain. When your transmitted audio sounds noticeably quieter than usual you probably have it close enough for some on-the-satellite-trials.

MULTI-BAND RIGS

An excellent alternative to the separate transmitter/receiver route is to acquire one of the multi-band units now available from all of the major equipment manufactures. These rigs , the YAESU FT-736R, the ICOM IC-970, and the KENWOOD TS-790 with the proper modules will work ALL of the satellites as well as be an excellent rig for general operating. If you can afford them they are an excellent way to go.

The original multiband rig, the Yaesu 726, can be found on the used market. With the appropriate modules, this rig will allow you to operate full duplex giving you a 2 meter FM uplink and 437 USB downlink. Again, consult the Elmers list.

ANTENNAS AND TRANSMISSION LINES

In the evolution of the Microsat concept no subject has been more controversial than antennas. Let me say that even as this manuscript goes to print the subject is still under investigation. Having said that, let's look at various types of antennas and see what can be expected both from a theoretical aspect and a practical one. The contributors to this Guide have tried all of the following systems at one time or another.

Assume that you currently have no capability for 70 centimeters or 2 meters. This Guide will start with the simplest system and go forward to the more complex. Your decision in part may be based on your ability with a hacksaw and your willingness to build your own.

For a pacsat station to function it must receive on 70 cm, (specifically 437 mhz) and transmit on 2 meters. So I will discuss the antennas in pairs. The simplest form of antenna is the 1/4 wave vertical both from a standpoint of cost and construction. Since each microsat will give you four passes a day at elevations of 6-60 degrees, this antenna and its low radiation angle will perform best at satellite elevation passes of 10 to 40 degrees. Let's say you can obtain or construct a pair of these antennas. What can you expect? Well, without a preamp on the 70 centimeter side and say 50 feet of RG-8 coax to the antenna, you will at least hear the bird during optimum passes and you may in fact decode some of the packets, but it will be marginal at best. A quarter wave vertical exhibits no gain and you will need substantial gain in your receiving system to adequately decode the downlink from one of the pacsats.

As the satellite goes overhead on a high orbital (about 20% of a pacsats passes are in this class) pass you will notice a definite drop in its signal strength, even though the bird is closer. That's because the signal is now outside the major lobe of the 1/4 wave vertical antenna. In theory, the relative proximity of the bird should compensate for this but in a marginal

system it simply doesn't. Don't despair, as there are still a lot of lower passes that will allow you to use your simple vertical effectively-if you use a good preamp and low loss feedline.

The next easiest improvement for many and in fact what most satellite operators consider mandatory is the addition of a receive preamplifier at the base of the antenna. This option can net you 10 to 20 dB of gain.(I will discuss preamplifiers in more detail later). Unless you already have a 70 centimeter beam of some kind a vertical with a preamp is the recommended place to start.

A simple 1/4 wave vertical antenna can be modified in several ways to obtain more gain. It could be changed to a 5/8 wave or to one of the collinear type verticals, such as Cushcraft's Ringo Ranger or AEA's Isopole to increase gain even more. But just remember as the gain of an antenna increases it looses its ability to be omnidirectional. Nothing is for free in this world. But by all means if you already have one of these type antennas give it a try; only then will you know what you can hear and decode with your system. A preamp is still mandatory with these antennas for acceptable performance.

An excellent article on the construction of a dual band J-Pole vertical antenna that was designed around the Microsat project appeared in the March 1990 Issue of **The AMSAT Journal**. This antenna coupled with a modest preamp will give you satisfactory performance. It is easy to build and the cost for the materials is very minimal. If you don't have a suitable antenna for either 437 or the 145 uplink my recommendation is to start by building one of the dual band J-poles. Then as you acquire a better antenna for one of the bands you can just use half of the J-pole! If nothing else read the article on its construction as it contains some extremely valuable information on the microsats. This article in its entirety is reprinted in the Compendium you received with this Guide.

The main disadvantage of the vertical antennas is that reception falls off sharply at higher elevation angles. Additionally the more the antenna gain is increased the deeper this null becomes. The second major disadvantage is that the vertical antenna has a linear polarization sense.

For those of you experienced with satellite reception, you will remember that the sense of the transmitted wave form from a satellite is circularly polarized. Knowing that, deep signal fades at the groundstation can be expected as the satellite's circular wave front precesses around the ground stations simple linear-vertical or horizontal- antennas. To be most effective a ground station's antenna system must also be circularly polarized.

For a more complete discussion of polarization sense, refer to Chapters 7 and 8 in the recently revised version (dated 1990) of

SATELLITE EXPERIMENTER'S HANDBOOK. Make sure you purchase the recent revision of this marvelous work as it has been totally rewritten specifically for someone with limited knowledge. You can read the **SATELLITE EXPERIMENTER'S HANDBOOK** and understand a tremendous amount of material about the whole spectrum of amateur satellites. AMSAT sells this book; you can also use the membership blank that came with this package to order this excellent reference.

Both the Lindenblad and Turnstile antenna attempt to deal with these circularity problem and are described along with construction details in the **SATELLITE EXPERIMENTER'S HANDBOOK.** These antennas are easy to homebrew and are a better unit for your station than a vertical.

BEAM ANTENNAS

I received a letter from a ham in the UK who is using his linearly polarized beam antenna manually elevated to 20 degrees and fixed to the east. He says he gets "pretty good reception". For those of you who have used AO-10 and AO-13, undoubtedly you have some type of high gain antenna array. Of course, they will provide excellent results when used on the microsats. The main disadvantage the high gain Oscar-10/13 arrays is that they are not Omnidirectional. In other words this requires that you point the antenna array (both azimuth and elevation) at the bird throughout the pass. This can be daunting with a narrow beamwidth, high gain array during a high elevation pass of a fast moving pacsat! Even more so if you have to try to type any commands into your PC! Thankfully this process can be automated by computer. Most of the Az/EL rotors on the market will interface with your computer and the appropriate interface card. AMSAT's top of the line tracking programs have the antenna steering program incorporated in them. With a good set of orbital elements and accurate clock settings, the process becomes automatic.

If you have standard beams used for FM or SSB they will work for the pacsats with excellent results. If you do not have an elevation rotor try what the Englishman did-elevate them about 20 degrees or so and have at it. You won't have lost much in your terrestrial operation and your pacsat operation will be satisfactory.

As always, each system has its advantages and disadvantages. I have found that a 5/8 wave with a good preamp and low loss coax can provide a good system requiring minimal expense. Again carefully study the Elmers list and give whatever antenna system you come up with a try!

Several excellent publications on antennas for VHF/UHF and Satellite are in print. Examples are ARRL Handbook, The ARRL

Antenna Book, The Satellite Experimenter's Handbook, and RSGB VHF/UHF Handbook.

TRANSMISSION LINES

Whichever route you choose, please pay particular attention to the transmission lines. At VHF/UHF frequencies the loss associated with feedlines becomes very important. For example, at 437 mhz a 100 foot length of RG-58 coax exhibits a loss of more than 5 dB. What this means is that between the time the signal leaves your antenna and arrives at the receiver, it has lost more than two thirds of its signal strength. On a marginal system, this can mean that the signal will not appear much above the noise-or more than likely not appear at all. For short runs (under 25 feet), RG-8/RG-213 may be adequate. Much over that distance, I strongly recommend a low loss cable such as Belden 9913. Over 100 feet, you should really consider hardline for your 70 centimeter antenna and perhaps 9913 for 2 meters.

Additionally pay particular attention to your connector terminations. UHF (PL-259s) type connectors may be okay at 2 meters, but at 70 centimeters, only "N" type connectors should be used. Most N-type connectors available at swap meets will not fit on 9913. There is an Amphenol connector (#82-202-1006) with a large center pin made for 9913. It is available along with Belden 9913 from Nemal Electronics, Inc., 12240 N.E. 14th Ave., North Miami, Florida 33161, (305) 893-3924. Certified Communications (see their add in QST) also has these connectors.

I would encourage you to use type-N fittings on your coaxial cable whenever possible. These connectors have very low loss and are very reliable. If you end up with a piece of gear with the standard SO239 or PL259, consider changing these to type N connectors, they perform much better for satellite usage. In some cases you can specify the type of connector when ordering gear. If you can specify type N.

Due to the construction of the N-type connector, the coax is held in place mechanically by the shield, rather than being soldered to the connector body as with the PL-259. Since 9913 has a foil shield with only a small amount of braid, the connector can support only a small amount of stress. I would strongly suggest some form of "stress relief" to prevent the weight of the cable from being supported by the connector (as at the drop from the bottom of your antenna). Heavy duty heat shrink tubing, overlapping both the connector and the cable by several inches, is one effective method of accomplishing this. In any case, 9913 is worth the effort.

Please pay close attention to weather-proofing your connectors and feedline system. Moisture intrusion into coax and associated

connectors will quickly degrade the performance of your carefully planned system. I use heat-shrink tubing or good electrical tape sprayed with clear Krylon over all my fittings. Also, the type-N connectors greatly reduces the possibility of water intrusion. Some hams use silicon type RTV sealant to assist in the waterproofing of their stuff. USE CAUTION HERE! If the "right" kind of silicone/RTV ISN'T used, more damage can be done in the long run than good. You must use a non-corrosive silicon/RTV. Most silicon and RTV sealants have acetic acid in them. That's why they smell like vinegar when uncured (wet). Do you intentionally want to use acid on your connectors and sensitive electronic gear? I don't! The run-of-the-mill stuff you get at your local hardware store IS going to be the corrosive type. Sniff it next time and note the vinegar like smell (no you won't get busted for sniffing this type of "glue").

The non-corrosive type is the only type which should be used. Dow Corning 3145 RTV adhesive/sealant IS a non-corrosive type and the only one I use on my electronic stuff. (I don't own Dow stock. I just don't know who else makes non-corrosive RTV.) It is worth the extra effort to find this stuff.

Take your time and assemble these N-type connectors "perfectly," accept nothing less. The ARRL handbook has excellent instructions on how to assembly these connectors. Most experienced UHF/VHF operators will attest to the importance of this step. Nothing is more aggravating than to find after a hard rain that the "N" connector on you 70 centimeter vertical mounted at 60 feet on the tower has managed to fill with water. Wrap the connection with a good grade of electrical tape as a minimum. Seal it with a spray sealer such as Clear Krylon. Let it dry and repeat the process. Once that's done, coat the entire surface with a coat of silicone/ RTV. Another option is to use one of the high grades of thick walled heat shrink tubing to weatherproof and strengthen these connections.

PREAMPLIFIERS, FILTERS, AND AMPLIFIERS

Possibly the most important piece of any satellite receiving station is the pre-amplifier. Pre-amplifier technology has advanced tremendously in the very recent past. New generation GaAsFET pre-amplifiers are capable of exceptional gains of 20 to 24 dB with almost no added noise (noise figure approximately .5 to 1 dB). In weak signal work, preamplifiers are a fact of life. Essentially it amplifies the incoming receive signal prior to its entry into the feedline or receiver. If your station incorporates some type of omnidirectional antenna, you will probably find the use of some type of preamp essential.

Normally you will find two types: the more common inline

receive only preamps and the ones that incorporate some type of RF sensing relay scheme that switches the preamp out of the circuit so you can transmit into the antenna. If you are going to use the 70 centimeter antenna exclusively for receive, then you can use just the straight inline version. If you are going to use your antenna to transmit, you must either acquire a switchable type preamp or build some relays and a sequencer.

There are a couple of options to consider.

1. Mast mount GaAsFET

2. GaAsFET in the shack

If you have more than 25 feet of feed line at 70 cm, you should consider mounting the preamp right at the antenna. Coaxial line and connectors not only add loss, but also will produce a certain amount of white noise at 70 cm. To overcome this phenomena, mount the preamp on a short piece of good coax right at the antenna or at the first connector location near the antenna. By doing this, there will be a larger signal to noise ratio and you won't be amplifying noise. Some preamps are made in a weatherproof housing (such as ICOM, Lanwher, SSB, Advanced Receiver Research, Etc) while others are not. The **SATELLITE EXPERIMENTER'S HANDBOOK** has a very complete list of these items-both in kit form and ready made.

I would recommend you carefully review the specifications of all the manufacturers and pick out one that maximizes the gain, minimizes the noise, and still meets your requirements. When I say meets your requirements, one of the things that must be considered is how the pre-amplifier you have selected passes transmitted RF. I have room for only one set beams, and must use them for local FM repeater work, sideband work, and satellite communication as well. Consequently I sometimes want to transmit relatively high RF power through these beams. For this purpose I chose a pre-amplifier that was designed to pass a large amount of power, but still offered high gain-and most important low noise figures. Such preamps can pass 160 watts, which is all you will ever need.

If you never intend to use your antenna for transmitting, preamps are available from the same manufacturers that cannot pass RF but are less expensive. However, if by chance you do transmit through these preamps, you will ruin them.

The pre-amplifier needs to be mounted as close to the antennas as possible. I mount mine on the vertical mast that holds the elevation rotor, just below that rotor. (If you are using a vertical mount it on the mast just below the antenna.) Consequently I have a short drop of coaxial cable from the circularly polarized downlink antenna to the pre-amplifier. I have found that this works exceptionally well. Use some of the more flexible low loss coax here like Certified Communications' Flexi-

4XL (a 9913 clone that is very flexible).

Check in the **SATELLITE EXPERIMENTER'S HANDBOOK** for sources of preamps; a lot of very good ones are available as kits. Before you buy make sure to also carefully review the Elmers list.

TNCs/PSKs/DSPs and other auxiliary boxes

A pacsat station must have a terminal node controller (TNC) to convert the digital information coming from the computer to audio information for the transmitter and receiver. Some of you may now be operating on "regular" packet. If you are, you're already familiar with much of what I will discuss here. All of the microsats are "digital birds" so to speak. None have analog transponders as FO-20 or AO-13 have. A TNC with the proper modem will allow your computer and radio to converse with the computer aboard the satellite.

Most TNCs will interface with your transmitter / receiver fairly easily. Some of the newer radios have a separate port called the "data" connector. It makes interfacing everything much easier. You will have to make several changes from the standard packet setup on your hookup since your station will be operating full duplex / split band. You will also have to add an outboard modem to the scheme and I'll discuss that in more detail. A caveat before you begin the wiring... pay attention to the cable construction. Build each one as though your life depended on it. This thing is complicated enough without having to run down a poor solder joint or a set of touching wires inside a sealed up din plug. A short in this hookup can cause the TNC to do some really strange stuff!

First lets look at the TNC (terminal node controller). If you don't yet have one there are a couple of things to look for. Make sure the unit will operate in the KISS mode, all TNC manufactured since 1986 include this protocol (More about KISS later). However some of the older TNC 2s and TNC 1s did not have the KISS software incorporated in the EPROM that's inside the TNC. But, many can be modified to run kiss. On a MFJ 1270B all I had to do was change the EPROM and even an old Heathkit HD-4040 TNC-1 only required a little rewiring, a switch and a new EPROM from TAPR (Tucson Amateur Packet Radio Corp).

Follow the manufacturers directions in setting up the TNC and use it for a while on terrestrial operations with a BBS or a friend until you become familiar with it before you attempt to interface it into your satellite station. (That way you will know it was working BEFORE.....).

The "connected" mode of the AX.25 protocol is used to upload and download files from the pacsat. In addition, a special broadcast protocol can also be used to just receive files. The advantage of the broadcast protocol is that many ground stations

can simultaneously receive a file, rather than each one of them connecting to the pacsat and requesting an individual copy of the file.

This broadcast protocol uses AX.25 "unconnected mode" frames. The program used to implement the broadcast protocol, called "PB", uses the KISS option in the TNC to receive these frames.

When you use the software written by the AMSAT team such as is included with this Guide, you don't have to do anything to turn on "KISS" - your software will do it automatically and shut it off when you exit. Just make sure the TNC you will be using has that flexibility.

A second thing to must look for in a TNC is the ability to interface a different modem other than its onboard modem. The onboard modem in a normal TNC uses AFSK (audio frequency shift keying). The pacsats use a phase shift keying technique. A pacsats' downlink is PSK in USB and the FM uplink when modulated by the PSK Modem is called Manchester APSK.

This change to PSK was made only after a lot of consideration and for extremely valid reasons. PSK can be decoded at much lower signal to noise levels than AFSK or FSK can. To give you an example, when I was testing the TAPR PSK unit that I built I used an audio tape that had recorded PSK signals on it. I set the level as weak as I could and didn't think it had a chance of decoding but it did. Many times the signal has been right down in the noise and it still clicked right along. That kind of performance is just not there in AFSK.

To take advantage of this PSK you will need to disconnect your TNC's onboard modem and interface the outboard PSK unit to the TNC. This is not as hard as it sounds. All the help you will need can either be found in the excellent docs that come with the units or from one of AMSAT's dedicated Elmers.

As for the PSK unit itself you have several options at this point. A complete unit ready to run is available from PacComm in Tampa, Fl. for $ 249.95. This is an excellent unit, basically an improved commercially built version of the TAPR kit unit. It comes with a very informative instruction booklet that gives step by step details of how to interface this rig with many different radios and TNCs. PacComm is also very helpful if you have problems making your components communicate correctly.

The G3RUH modem from RadioKIT in New Hampshire is also an excellent unit. Look in a late issue of QST or in the **SATELLITE EXPERIMENTER'S HANDBOOK** for the name and address of this organization. They also have a lot of other equipment that can help you-ask for a catalog.

The TAPR kit is available for $125. It is also a great value! But, I repeat BUT it is not simple to build or test. You must have access to some test equipment. If you have never built a kit before you may find it very difficult. Troubleshooting skills may become necessary. In the March, 1990 issue of **The AMSAT Journal** is a very good article by Jim White, WD0E, on the construction of the TAPR PSK modem.

Regardless of which way you go you will have to interface your PSK unit with

1. your computer
2. Your TNC
3. Your VHF transmitter
4. Your UHF receiver

Use a full RS 232 cable to the computer from your TNC (The software called PG needs it). The modem disconnect header will provide part of the wiring to your TNC along with a simple DIN cord you can buy or build. The VHF radio will require full transmit and receive cabling if you are also going to use your unit for standard 2 mtr packet. Your UHF unit will require receive cabling along with AFC (automatic frequency control) cabling. A switch on the front panel will provide you with control over 2 mtr AFSK and split 2 meter/70 centimeter split operation. If your radio has the ability to remotely change frequency (with the mic clicks) you can use the AFC from the PSK unit. As discussed previously in dealing with the reception of any satellite the Doppler Shift of the downlink must be considered. In simple terms the satellite downlink frequency in any given pass will appear to drift. It will start out high, as it passes your location be right on very briefly and as it goes away it will appear lower and lower. With the Microsats this shift is about 15-20 KHZ in a 10 to 15 minute period that constitutes a pass. For example AO-16 shows up around 437.035 and disappears around 437.017 for most locations.

PACSAT caries two transmitters: one regular and one raised cosine. When tuning for a lock on the normal transmitter (usually every day but Wednesday UTC) you may get a carrier lock on a "harmonic" rather than the true signal. If no data starts coming through in 10 or so seconds try retuning.

The other transmitter is called the "Raised Cosine" downlink. Don't get hung up on the description of this. This is simply an experimental transmitter that has attempted to suppress some of the harmonics that will frequently be strong enough to capture your PSK modem and hence lock the receivers VFO on that "dataless" signal. Through electronic wizardry these harmonics have been suppressed about 10 to 15 dB more in the raised cosine downlink. But as always at some cost-the overall downlink signal is at a lower power level. Try to keep a record as you become proficient at the operation of the pacsats and record if this raised cosine beacon is really easier to lock onto the signal containing data.

TRACKING-OR IF YOU CAN'T FIND IT YOU CAN'T WORK IT!

Well, "you sure can't hear them, if you can't find them," I guess is one of the new maxims of amateur radio in the era of amateur radio satellites. Knowing where to point your beams or when to listen for a pacsat can sometimes be a bit tricky, unless you have the right equipment. The best way to perform this tracking function is the computer method. Since you probably have a personal computer (packet is REAL hard without one), AMSAT can provide you with an excellent software program which gives you precise details on when to listen and where to point your antennas. A listing of these is in the Compendium that came with this Guide. Even if you are using a vertical you will need to know when the satellite comes up and goes down.

Before the program that you purchase from AMSAT will work it will need a current set of orbital elements.

Orbital elements are the set of parameters that describe the orbit for the specific satellite in terms that the computer can understand. They are available several places such as in **The AMSAT Journal**, usually on the ARRL's information broadcast from W1AW, on the AMSAT nets, and probably on a packet bulletin board that you can access and, of course, on the pacsats. To assure accurate predictions for the pacsats the element set should be no older than a couple of months. Updating them every week is not necessary, however. When running the printouts, since pacsat move relatively rapidly, I find that one data point every minute is enough.

In the discussion above I stressed buying this program from AMSAT. There is a very important reason for this that I hope you will try to understand and embrace. AMSAT derives much of its income from its sale of software. This is the same income that funded some of these pacsats-No software sales equals no satellites! So please buy a copy of the program of your choice from AMSAT-you can use the attached order form-and resist giving it to you friends.

If you catch them doing that please explain to them that what they are doing is bad for amateur radio and ask them to refrain from same.

SOFTWARE

The software suite on the included diskette contains all the software needed to work the pacsats. The disk is set up to auto load on to the hard disk of your PC. BEFORE YOU DO ANYTHING MAKE A BACKUP DISKETTE. Also please thoroughly read the README file on the diskette as it contains explicit information on how to load the

software on your PC.

After you use these programs for a while I am sure you will find a better way to configure you PC. But for now just do it the way that is discussed in this Guide so you can get started quickly. What I have done in these subdirectories is to configure the software programs in the fashion currently recommended by the Microsat command team and set up some very simple subdirectories to help keep the satellites straight.

The diskette will set up and partially fill the following subdirectories:

AO16
LO19
PACDOC
ZIP
DOWNLOAD

The diskette may also have on it a file called ORBS.XXX which are the orbital elements that can be autoloaded into the software you are going to buy from AMSAT! These orbital elements were downloaded off of the satellite-your next source of info on the amateur satellite program! (Hint:Look in the .DL files for this file.)

One of the files located in each of the two satellite subdirectories is called "pg.cfg" and looks like this for AO-16:

```
ao16access 30660
bdcstcall pacsat-11
bbscall pacsat-12
mycall N4IFD-0
port 1
speed 9600
graball 1
log_kiss 1
log 1
maxdupes 10
restart_delay 54
break_delay 36
maxsel 30
```

You need do a couple of things to this file before you try to run the rest of the programs. First-put your call in place of mine, Next- check that you TNC is capable of communicating with your PC at a speed of 9600 baud. If not change that line accordingly (it needs to be 2400 or higher). Finally- change the "port 1" as appropriate for you PC's serial port. Make these same changes in the similar file in the LO19 subdirectory. You are ready to copy your first pass on AO-16.

You have no doubt noticed that the subdirectory for LO-19 contains ONLY the PG.CFG file that is specific to LUSAT. This was to save disk space on the distribution diskette. Please copy all the other files (except PG.CFG) from the AO-16 subdirectory into the LO19 subdirectory. It will then be ready to copy the downlink from LUSAT!

As you begin to run these programs other files will be created and placed appropriately in these subdirectories.

The present release of the PACSAT Groundstation Software consists of four programs which implement the PACSAT protocol suite described in a paper by Harold Price, NK6K and Jeff Ward, G0/K8KA in the 9TH ARRL Computer Networking Conference Proceedings. These protocols and programs introduce a new type of "BBS" operation to amateur packet radio. In standard BBS operation, you connect to the PBBS station and are treated like a remote terminal user. In the PACSAT system, however, your computer connects to the satellite's computer and the two exchange messages efficiently using automated procedures.

This automated approach requires standardization of procedures and data formats. The protocol specifications - collectively called the PACSAT Protocol Suite - specify a standard file header format, a broadcast protocol, and a connected-mode file-transfer protocol. This file-transfer protocol is referred to as "FTL0".

The ground station software was written by Jeff Ward, G0/K8KA, at the University of Surrey in England. It includes the following programs:

PB.EXE - Receives broadcasts from PACSAT. After you have received a broadcast file, you must process it with PHS.EXE to put it in a format that you can read easily.

PHS.EXE - Displays PACSAT File headers, and removes headers from files which have been downloaded from PACSAT. PHS.EXE is the complimentary program to PFHADD.EXE. These headers are attached to the files to facilitate a pacsat's handling of the files.

PFHADD.EXE - prepares files for uploading. Only files which have been processed by PFHADD.EXE may be uploaded to PACSAT.

PG.EXE - implements the connected-mode file transfer protocol called FTL0. PG.EXE can be used to obtain lists of files which are on PACSAT, to download files from PACSAT, and to upload files to PACSAT. Before uploading a file to PACSAT, you must prepare it with PFHADD.EXE. After downloading a file from PACSAT, you must process it with PHS.EXE.

Do your best to keep up with changing versions of these programs. Some new versions will be bug fixes and some will contain enhancements. While it remains practical, the newest versions of these programs will be available on the satellite. If it is a while before you actually have a chance to try these on the satellite, check with the AMSAT Headquarters for the latest revision of the PB/PG software suite. For a small donation the latest software will always be available there.

There are several executable files in these subdirectories that need explanation before you run them. **Be aware some of these programs (PG & PB) will not run unless you PC is connected to the PSK1/TNC and they are powered up!**

The program I would suggest you run first is PB. Change into the AO16 subdirectory and type " PB" followed by a return.

The PC should begin to scroll many messages across the screen and wind up with a nice screen that looks like the one on page 23. If it doesn't most likely there is a communication problem with the TNC or PSK. Recheck all your cabling -try the TNC on a local packet BBS and determine if that part of your system is operational. Next, carefully reread the instruction books before as a last resort you call on one of the Elmers.

PB is the program you will use to tune in the satellite and just copy what ever file it is broadcasting on the downlink. It requires less time to get up and running with this program because it doesn't even know or care if your transmitter exist.

After you have the screen like the example on page 23 up on your PC press the letter H and D to tell the program to display all the file headers as they are broadcast along with the data being broadcast. The display of these headers/data is the most certain way to tune in the right part of the downlink signal. Make sure the "H" and "D" on the bottom line of the screen are on! You will note that the G and K commands have already been invoked by the software setup commands. The G or Grab command is the one of interest as it lets you capture all the files being broadcast by the satellite. Then all you need do is tune in the downlink as the satellite comes up and goes by.

Tuning can sometimes be a bit tricky. I find it works best when my downlink receiver is on USB and I have set the audio just a little higher than a quarter up from off. (Too much audio will cause difficulty with the PSK's tuning-if it uses speaker output audio versus some fixed level audio output.) Start tuning well above where you expect the satellite to be-for instance about 437.037 for AO-16 and slowly tune down toward the published downlink frequency of 437.025. Keep going back and forth like this until you hear the downlink. This process is much less time consuming if you have current elements in your tracking program and

are using an accurate time source in your shack. About the time the program says the satellite will rise you should begin to hear the soon to be familiar sound of PSK. Keep tuning above where you first hear this sound and slowly tune down on it while watching the display LEDs on the front of the PSK modem. It will indicate "lock" as the PSK modem locks on to the PSK downlink. At this point you probably will not see anything beginning to scroll across your screen, You have probably locked onto one of the vestal sidelobes of this signal. Keep tuning slowly on down until you acquire the next lock-this should be the one and momentarily the headers being

```
File #     ¦Holes¦File size ¦Pkt Offset ¦                                  Files Heard
0x00000f55     4  Unknown     0x00001100                                   0x00000f55
0x00000f54     3  0x00000ad3 0x00000100                                   0x00000f54
Inactive.
Inactive.
Inactive.
Inactive.
Inactive.
Inactive.
Inactive.
Inactive.
Total bytes in: 0x0000101d ¦ CRC errors:       ¦
[PACSAT-12>WB6LLO :   : I Nr=1 Ns=1 P=1 Data=4 PID=0xf0]
[PACSAT-12>KI6QE :   : I Nr=1 Ns=3 P=0 Data=2 PID=0xf0]
[PACSAT-12>BBSTAT :   : UI]
Open  BC : WB6LLO KI6QE
[PACSAT-11>QST-1 :   : UI]
[PACSAT-11>QST-1 :   : UI]
[PACSAT-12>KI6QE :   : RR Nr=2 P=1]
[PACSAT-1>TIME-1 :   : UI]
PHT: uptime is 018/13:49:19.  Time is Mon Apr 08 18:25:02 1991


pb.exe [901221m] ¦ COM1: 9600 ¦ PACSAT-11 ¦ N4IFD-0 ¦ Flags: GH
Begin. Cap. Grab. Hex. Data. Heads. Txd. Info. Shh. Kiss log. Quit. ? help.
```

broadcast by the pacsat will start to fill the lower half of the screen. this sometimes takes 10 or 15 seconds so be patient! If this doesn't work right the first time don't give up just keep tuning slowly from above the signal until you acquire lock and data begins to scroll across the screen. You may tune through several locks before you get locked onto the signal with the data stream. Be patient, you will get much better at "hearing" which is the right signal in a short time.

Another way to check this is as the tuning LEDs on the PSK illuminate and move toward the center indicating that the PSK signal is locked watch the "CON" light on the front of the TNC. When it first flashes you are exactly in the right spot-let go of the VFO! Simultaneously data and headers will begin to scroll down your screen! You are locked onto the center of the downlink; take your hand off of the VFO and the PSK modem will take over the tuning chores while you just sit back and watch the files come down and the headers go by.

The only problem that you must watch for is if the bird takes a deep fade (20 dB or so) the downlink may unlock causing loss of data. If you don't retune manually the PSK will just kind of twiddle around the last frequency while the bird goes south on you. If this happens, go back to basics-quickly tune above the signal and look for the signal containing data.

As the files begin to come down the upper right hand part of your PB screen will begin to fill up with the hex file names of the files being put into the broadcast mode by the satellite's CPU. In the upper center portion of the screen the number of holes in the file will be tracked while the lower portion of the screen will basically perform like your packet screen does when you have MON set to ON.

When the pass is over you then will be able to read what you have gotten off the pacsat. As you ask the PB program to"Quit" it will write something called hole files to the disk. These tell it what partial files it captured during this pass so it will only look for fills on those files next time around. The files that are successfully downloaded will be stored as a hexadecimal number followed by the extender "dl" indicating they are complete downloaded files. Usually your PC will beep during PB operation indicating it has completed the download of a file and the bottom line of the screen wiLl say **"YO FILE XXX IS COMPLETE."** These files can then be read by using another one of the programs on the diskette, the Pacsat Header Show routine or PHS.EXE. I have included some .dl files on the diskette for practice with PHS.EXE. Some of these files are actual programs that will help you with your pacsat operation. Take some time and unlock each of them.

I make a copy of all the .DL files after each pass in a separate subdirectory in order to keep them as sort of a history

file. I then move them out of the satellite subdirectory to a "Read" subdirectory where I can extract them with PHS and read them.

Frequently these files are Zipped and you will need PKUNZIP to open them up. I have put it along with all the ZIP shareware programs on the diskette that came with this Guide. Some of the .DL files I have given you are zipped. Run them through PHS and read them. This will give you the opportunity to practice using the .ZIP protocol with some of these files.

Work on becoming good monitoring the pacsats with PB before you attempt to involve your transmitter/uplink system. As with all Amateur satellite communications-work on your receive station and perfect it before you begin to transmit. Don't hesitate to contact me or one of the listed Elmer's if you can't get PB to work. Chances are we had some of the same difficulties.

GOOD OPERATING PRACTICES

Amateur radio can not prosper without all amateurs understanding what "good operating practices" are and using them continuously. Using amateur satellites is no different; in fact is more important that you understand these as they apply to the satellites and always operate in the correct manner. Before this Guide takes you any further and certainly before you begin any transmitting up to a pacsat the following should be thoroughly familiar to you.

The first good practice that comes to mind is the oldest one around--LISTEN BEFORE YOU TRANSMIT! This applies just as much to satellite and microsat operations as it does to any other facet of amateur radio operations. Since I cannot " listen to the noise packet radio makes and tell what is happening I must rely on what my PC is telling me as it decodes the packets. Here is what you should do BEFORE you hit the "B" key in the PB program and before you do anything in the PG program.

After you have the satellite's downlink locked in and are getting text on your screen check for the following:

a) Is the PBBS in operations? Monitor and look for the BBSTAT (Bulletin Board STATus line). Is it there? If not, the BBS isn't running and trying to "work" it will cause needless QRM. If is there it will look something like this:

PACSAT-12>BBSTAT:Open -This indicates all 4 (A-D) uplink channels are open waiting for someone in PG to make a request

PACSAT-12>BBSTAT:FULL KG4TM KB9CML VE1HD WB9ANQ or something similar would indicate it was full-wait before using PG for

a request-you can use the "B"-Begin file download command in PB at this time however as that is a separate function of the pacsat.

b) If the you don't see the BBSTAT (bulletin board status) line, please look for the LSTAT (link status) line. IF the LSTAT line indicates d:0 then the digipeater is out of service-DON"T TRANSMIT If d:1 then all is well you may transmit if the pacsat is not otherwise busy. Does it start with an "A"? If so, the BBS and digipeater are not available as code uploading is in progress. Users should NEVER transmit when uploading is in progress. These will look something like this on your screen:

A: 0x14C9, P:0x3000/ o:0 1:8700 f:8711 d:0 st:3 the **d:0** is the key on this line that indicated that the digipeater and the PBBS are not available-so don't transmit!

c) Check the plain ASCII text frame (>AMSAT for example). Command stations will usually post a brief message here saying what's going on with the satellite --like reloading code, everything's ok so use me, I'm switching to the raised cosine transmitter tomorrow, etc. This might look like:

File system is being loaded at this time. BBS should start soon 73 de AMARG This is an actual message from LUSAT during a reload.

d) Don't see any of the above but hear a signal? The bird is in MBL(the base or command mode) mode. Don't even think about transmitting--she's broken! the headers in a state like this would look something like this

PACSAT-12:MBL
PACSAT-12:MBL if it looks like this don't transmit; someone is trying to fix the pacsat.

USING PB TO REQUEST FILES

After you can copy the downlink reliably the next step is to complete the hookup and deviation set-up of the transmitter. I would suggest the first way to try your uplink system is to invoke the "B" command of PB. The PB screen will indicate under the "Files Heard" column several file names in Hexadecimal representation. Pick on of these say e92 and ask the pacsat to put that file in its "broadcast" mode. You do this by depressing the "B" key, the program will then ask in what size packets you would like to receive this file-answer by keying in 128 and hitting return. Your transmitter will now key up briefly and ask the pacsat to place this file in the broadcast rotation. The channel you would use to

request this bulletin will be discussed shortly.

There will be no acknowledgement back to your station of the satellites reception of this request other than a confirmation that will be broadcast on the downlink. An example of this is shown on page 28. This page is a "screen print" from my PC. My experience is that I don't always see the small "OK" on the downlink; even though I will usually start to see the file I ask for begin broadcasting within a few seconds. You can tell which file is broadcasting when its designator is highlighted.

In the previous text the term "PACSAT-12" was used; the screen print has the term "PACSAT-11" instead. the -11 indicates activity by the broadcast side of the pacsat while the -12 indicates activity by the PBBS side. You might also have noticed that both designators are in the PG.CFG file. To digipeate through the pacsat you would use the -11.

Pacsats are actually built to be "two" satellites in one. One part of the satellite continuously broadcast selected files and is available for digipeating while the other is dedicated to the PBBS functions. There are not really two satellites as these two functions share the four uplink channels and the one downlink channel.

Recommended Operation Procedure to Reduce AO-16 Uplink Contention

The AO-16 command team recommends that users of the AO-16 PBBS system use only channel D (145.960 Mhz) for downloads and directory requests leaving channels A, B, and C (145.900, 145.920, and 145.940 Mhz for file uploads, digi users, and bulletins requested through PB. Even if all four users who are logged on at a given time are doing downloads or directories, contention on uplink channel D should be minimal. This is because the single downlink channel from the satellite sends packets to each of the stations sequentially. When one station receives its packet, it will acknowledge on the uplink while a downlink packet is sent to the next station. Since no two stations will be receiving packets on the downlink at once, no two stations should key up to acknowledge at once if their TNC parameters are set correctly. The current version of the file server only allows four connected activities at a time. Use of one of the new PG.EXE versions, (release date either February 6 or February 7, 1991) will help too. These versions of the upload-download- directory software monitor the downlink for open BBS slots and attempt to initiate connects to the satellite only when first commanded by the user and thereafter only when BBSTAT indicates an opening. For uploads, please tune to a channel that is indicated to be open in the BBSTAT message, for downloads, please tune to channel D (145.960). Stations uploading files should stay off of the download/directory channel D as their longer uplink packets will collide with acks uplinked from downloading stations. Stations doing downloads should stay off of

```
File #     ¦Holes¦File size ¦Pkt Offset ¦                          Files Heard
0x00000e76     5  Unknown     0x00001300                          ¦ 0x00000e76
0x00000e02     4  Unknown     0x00001b00                          ¦ 0x00000e02
0x00000e92     1  Unknown                                         ¦ 0x00000e9e
Inactive.                                                        ¦
Inactive.                                                        ¦
Inactive.                                                        ¦
Inactive.                                                        ¦
Inactive.                                                        ¦
Inactive.                                                        ¦
Inactive.                                                        ¦
Total bytes in: 0x00001598 ¦ CRC errors:0002  ¦
[PACSAT-11>QST-1 :  : UI]
[PACSAT-11>QST-1 :  : UI]
[PACSAT-11>QST-1 :  : UI]
[PACSAT-11>QST-1 :  : UI]
[PACSAT-11>QST-1 :  : UI]
[PACSAT-11>QST-1 :  : UI]
[PACSAT-11>N4IFD :  : UI]
OK
[PACSAT-11>QST-1 :  : UI]
[PACSAT-11>QST-1 :  : UI]

Requesting file 0xe92 with 244 bytes per frame.
Begin. Cap. Grab. Hex. Data. Heads. Txd. Info. Shh. Kiss log. Quit. ? help.
```

channels A, B, and C since their frequent but short ack packets will collide with longer uplink attempts seriously degrading uplink performance. As AO-16 and the other new pacsats become more popular, various experimental techniques like this will be recommended in order that the new satellites will be able to accommodate as many users as possible as expeditiously as possible.

Recommended AO-16 operating practice in summary:

Downlink: 437.025 Mhz (437.050 and 2400.143 on experimenter's day.)

Uplinks:

145.900 A uploads
145.920 B uploads
145.940 C uploads
145.960 D downloads and directories
Either A, B, or C may be used in PB for the "B" command.

Note: the above operating suggestion was in a file to "ALL" that I downloaded off of AO-16. This is current practice of PACSAT; please use it until something different is published-watch the satellite!

NOW COMES THE UPLINK!

Now comes the real challenge using PG to select files from the directory aboard the pacsat; asking for downloads of those files; and then the real purpose of reading all this stuff-uploading your first file to the Pacsat File Server.

After you are comfortable with the PB program and have your transmitter's deviation adjusted you are ready to try the PG program. This comes up with a screen somewhat like PB but allows you to upload files to the satellite as well as request directories from the satellite and then based on that directory ask for downloads of specific files.

When the bird comes up tune it in with PB as before and the moment you are sure that lock is achieved depress the "Q" to exit PB. Immediately key in PG and hit return. The PC will start to load the ground station software into your PC. When that screen comes up depress the "B" key that will give you a listing of all the "Bulletins" on the pacsat. Bulletins in this context are those files uploaded by various amateurs that are addressed to ALL-things of general interest. If everything in your station is correct the pacsat will come back with a screen like the one on page 30, or you will get the message:

PACSAT BUSY:

Either way you have done it; you have linked to the satellite. If nothing happens after a few tries; go over everything again and

```
cmd:PACSAT-12>BBSTAT:FULL A    : KG4TM  KB9CML VE1HD  WB9ANQ
PACSAT-12>BBSTAT:FULL A    : KG4TM  KB9CML VE1HD  WB9ANQ
PACSAT-12>BBSTAT:Open
 A    : KB9CML VE1HD  WB9ANQ
cmd:
connect pacsat-12

Logged in at Mon Apr 08 02:45:37 1991
PACSAT protocol server version 00.
Selecting ALL FILES newer than Sun Apr 07 00:00:18 1991
Selected : 28 files.
Requesting directory.
Bytes received: 1891
Directory successful.
Requesting directory.
Bytes received: 1625
Directory successful.
Requesting directory.
Bytes received: 1337
Directory successful.

cmd:d
cmd:
LINKED            To abort, hit the ESCAPE key.
Quit. Upload. Download. List Mine/Bulls/All/One. View dir. Terminal. Utility.
```

PACSAT BEGINNER'S GUIDE REGISTRATION FORM

NAME, CALL

ADDRESS

CITY STATE ZIP

PLEASE ENCLOSE $5.00 FOR THE REVISED VERSION OF THIS GUIDE. IT WIIL BE AVAILABLE IN SEPTEMBER OF THIS YEAR

SEND TO:

AMSAT
PO BOX 27
WASHINGTION, D.C. 20044

COMMENTS ON THE GUIDE:

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